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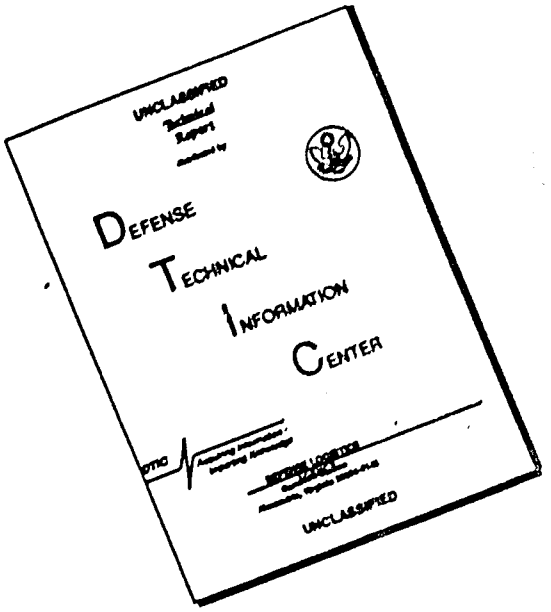

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15 March 1956

5R3N1

MAXIMUM CARGO CAPABILITIES OF TRANSPORT VEHICLES (U)

Part V - Combat Zone Transportation - Helicopters (Interim)

by

Pfc Thomas H. Starks

Copy no. 2

15 March 1956 No. 5R3N1

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ORDNANCE MISSILE LABORATORIES
Operations Research Office
Redstone Arsenal
Huntsville, Alabama

LIBRARY ABSTRACT

This report gives the cargo-carrying capabilities of helicopters available for use during the period 1956-1960, and forecasts the capabilities of those which will likely be available in the 1960-1970 period. Emphasis is given to external loading, with comments on the possibility of increasing tonnage and carrying capabilities by use of multi-helicopter lift over short radii of operation.

MAXIMUM CARGO CAPABILITIES OF TRANSPORT VEHICLES

Part V - Combat Zone Transportation - Helicopters

CONTENTS

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LIST OF ILLUSTRATIONS

MAXIMUM CARGO CAPABILITIES OF TRANSPORT VEHICLES

FOREWORD

To comply with military characteristics for missiles and rockets, it has become necessary to consider configurations and weights in excess of those encountered in previous antiaircraft and artillery ammunition. This creates a need for establishing maximum configuration and weight of a single item that can be handled by all modes of transportation so that the design of a weapons system is not in excess of transportation capabilities. Should the transportation and handling capabilities be exceeded, the tactical employment of such a system becomes infeasible.

This report, when completed, will establish the maximum size of a single package that can be handled by all modes of transportation. As a result of inquiries made upon the Office, Chief of Transportation, and other agencies, the Department of Defense became interested in establishing limitations within which design of weapons must stay for effective transportation and handling in tactical employment. It has directed that criteria be established on a uniform basis for all services. However, prior to availability of Department of Defense standard criteria, information that is presently available will be published for interim guidance to the designer of ordnance equipment. This information will be labeled Interim on the title page until superseded by Department of Defense criteria.

In order to disseminate information as it becomes available, this report will be published in six Parts:

Part I Air Transportation (published 29 Aug 1955, Rpt 5R3P)
Part II Water Transportation
Part III Rail Transportation
Part IV Road Transportation
Part V Combat Zone Transportation
Part VI Summary of all Modes of Transportation

Part V - Combat Zone Transportation - Helicopters

INTRODUCTION

This report outlines maximum cargo tonnages that may be transported internally and externally by helicopters and establishes approximate dimensions that may be transported by internal loading during the period 1956-1970. Information presented was obtained from Bell Aircraft Corporation, Hiller Helicopters, Hughes Tool Company, McDonald Aircraft Corporation, Piasecki Helicopter Corporation, Sikorsky Aircraft, and from the Air Force Brown Book of Standard Aircraft Characteristics.

Since the Brown Book criteria are the approved and accepted specifications for the using services, these maximums for weights, ranges, etc., were used for the helicopters for which they were obtainable (i.e., H-19D, H-21C, and H-34A). Standard Aircraft Characteristics are not available for the H-37A and helicopters being designed by industrial manufacturers for the 1960-1970 period. Information received from the various manufacturers concerned with

these helicopters has been used to predict what could be available should an agency within the Department of Defense see fit to further the development and production of these craft.

Maximum rectangular package sizes and weights that may be loaded internally are included for craft where this information could be obtained. When maximum package size is given, it means that the actual package plus any loading device used cannot be larger than the stated size. Non-rectangular packages may, in some instances, exceed the size limitation by small percentages. It is suggested, for non-rectangular items, that templates of cargo craft and packages to be transported be utilized to establish final maximum dimensions.

The possibility of utilizing vertical take-off and converter planes in supplement to or replacement of helicopters was considered. The Kellett Aircraft Corporation has a design for a tilting wing craft for which they predict a carrying capability of 30,000 pounds. Since this craft and other versions of cargo-carrying, vertical take-off and converter planes are in such an early development stage, this report will not attempt to predict the possibilities these craft will offer during the period 1960-1970.

DISCUSSION

Both internal and external loading of helicopters will be discussed in this report. External loading offers the following advantages:

1. Packages of larger dimensions may be transported.

2. Pick-up and sling devices reduce the loading time required, as compared to the time required for internal loading.

3. For short radii of operation the tonnage-carrying capacities of the helicopter can be increased by approximately the amount of weight saved in the removal of the fuselage of the craft. For this to be done the design of the airframe must be such that members supporting the external load will withstand the additional stresses created by this type operation.

When longer radii (50 to 100 miles) are being considered, some of the weight advantage will be lost due to the additional fuel required to compensate for the parasitical drag of externally suspended items. The exact amount of penalty to be paid will vary with the prevailing conditions, i.e., the amount of parasitical drag will be proportional to the configuration of the package being transported and the velocity of the helicopter. The net amount of weight advantage to be gained in the 50 to 100 mile radius by external loading was estimated by the companies queried. These estimates varied from 0 to 25%, with the average estimation being 6%. Again it is noted that the aerodynamic properties of the package being towed will directly affect the net weight gain, and before an accurate estimate can be made, the configuration and dimensions of the package to be transported must be known.

Since the Air Force Brown Book of Standard Aircraft

Characteristics gives consideration only to internal loading in its payload vs range curves, this report will assume that the payload-range curves will be the same for external and internal loading.

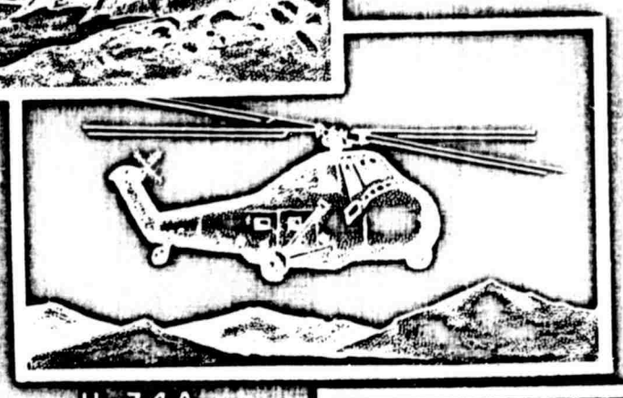
A survey of the helicopter industry was made to determine the planning of the industry with respect to future helicopter development, as well as to determine the capacities of craft presently in production. From this survey it was found that four cargo helicopters determine the maximum capabilities of helicopters in the period 1956-1960. Also, it was found that four new cargo helicopters are being planned and, if accepted and purchased by the Department of Defense, could be available in the 1960-1970 period.

A multi-lift type cargo movement has been proposed by Piasecki Helicopter Corporation. The method which they envision for this type operation was included in a proposal to the Transportation Corps. It appears from information contained in this proposal that three H-21C's could carry a load of approximately 6 tons over a short distance (see Fig 1). Using a similar system with five H-16B's, a load of approximately 30 tons could be transported over a short distance. The Marine Corps has tested a multi-lift method at Quantico, Virginia; however, final reports of the success of this activity, or any statistical information regarding tonnages, radii of operation, etc., had not been compiled at the writing of this report. Should multi-lift operations prove

feasible, the capabilities of present and future helicopters would be substantially increased.

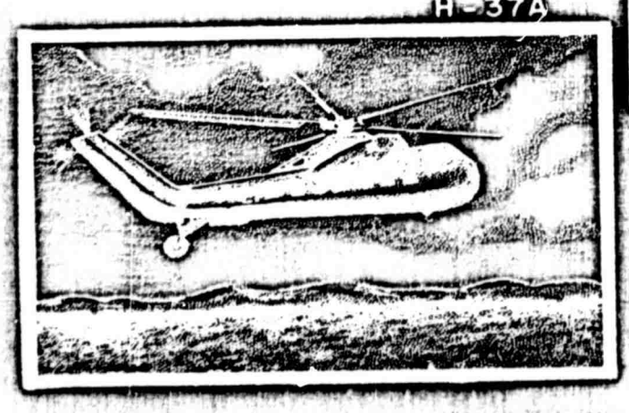
Cargo Helicopters 1956 1960

H-21C



H-34A

H-19D



H-37A

Period 1956-1960

H-19D: The principal mission of the H-19D is the transportation of cargo and assault troops. This craft has a single lift rotor and a small anti-torque rotor in the rear.

The main cargo entrance is 4 feet by 4 feet and is on the side of the helicopter. The cargo compartment is 10 feet long, 5.5 feet wide, and 6 feet high. An external cargo sling capable of carrying 2,000 pounds is provided.

Fig 2 shows payload-range and hovering capabilities of this helicopter.

H-21C: The principal mission of the H-21C is to provide air transportation for troops and cargo. It is tandem rotored, with a single engine, and has an automatic pilot and instrument arrangement for blind flying.

Fig 3 shows payload-range and hovering restrictions. The table below gives the maximum size packages that can be loaded internally in the H-21C.

Depth	53 ← → 53													59 ← → 59								
Width	46	40	38	36	34	32	30	28	26	24	22	20	18	34	32	30	28	26	24	22	20	18
Length	25	42	44	56	59	61	63	67	72	80	85	93	95	59	59	64	64	64	75	78	89	91

The H-21C has structural provisions in its fuselage for installation of an external cargo sling capable of carrying approximately 5,000 pounds.

The resultant change in center of gravity due to swaying of the external load is negligible from a control standpoint. The sling features a quick release mechanism, operable from either the cockpit or cargo compartment. The release mechanism opens the sling's cargo hook to enable dropping a suspended load at any time during flight or for instantaneous unloading while hovering.

H-34A: The principal mission of the H-34A is also the transportation of cargo and personnel. The H-34A is a single-engine helicopter using a single main lifting rotor and a single anti-torque tail rotor.

The cargo door, measuring 4 feet by 4 feet 3 inches, is on the side of the fuselage. The cargo compartment is 13 feet 6 inches long, 4 feet 9 inches wide, and 5 feet 10 inches high. There are provisions for a cargo sling capable of holding 2 tons of bulky equipment.

Fig 4 gives the payload-range and hovering capabilities of this helicopter.

H-37A: The principal mission of the H-37A is the transportation of cargo and personnel. It has one lift rotor and a small anti-torque rotor. This helicopter is a modification of the Navy model XHR2S-1 which had its first flight in January 1954. The H-37A should have its first flight in March 1956.

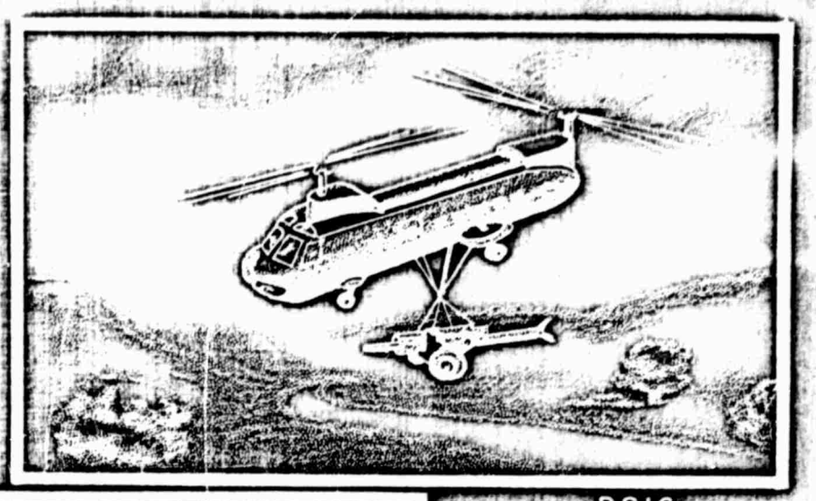
The helicopter is equipped with an external cargo sling capable of holding 10,000 pounds. The main cargo entrance is through the

clamshell doors in the nose. The cabin contains a 2,700 pound capacity monorail for use in loading. With the monorail in position the cabin clearance is only 69 inches; otherwise the maximum clearance is 80 inches. Fig 5 shows the cargo compartment and entrance.

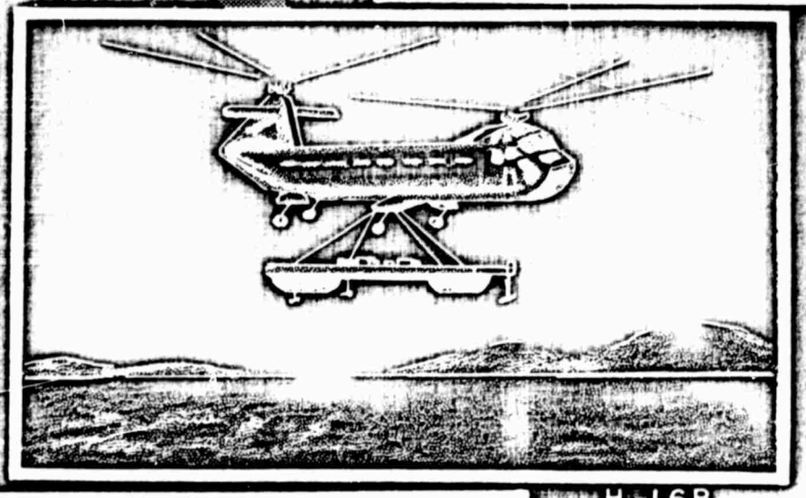
The H-37A will be able to carry a 6,000-pound package over a 100 mile radius and has a hovering ceiling of 6,400 feet with this load on a standard day.

Cargo Helicopters

1960

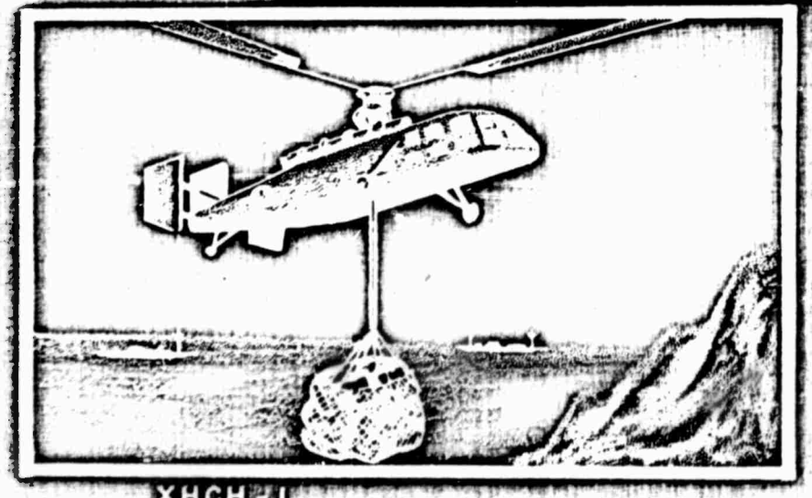


D216



H-16B

1970



XHCH-1

Period 1960-1970

YH-16B: The principal mission of this helicopter is to provide air transportation for troops and cargo. It is a tandem rotored helicopter with two turbine engines.

The cargo compartment of the YH-16B is approximately 48 feet long, has a maximum clearance of 6 feet 6 inches and a maximum width of 8 feet 9 inches at the heavy frames; but, since the cross-section of the cargo compartment is approximately semi-circular, Fig 6, a box whose cross-section is 6 feet 6 inches by 8 feet 9 inches could not be loaded. It appears from the blueprints that a box 5 feet high, 6 feet wide, and 41 feet long could be put in the compartment. The reader should again be reminded that any loading devices must be included in package size.

Fig 7 shows the capabilities of the YH-16B and possible improvements that may be made in later models.

It appears that this helicopter could be in production by 1960 if so ordered by the Department of Defense.

D216: The D216 is a tandem rotored, tri-turbine powered, cargo helicopter proposed by Bell Aircraft Corporation. This helicopter is designed for handling loads of approximately 3 tons. The D216 will not set a maximum on the helicopter transportable package size in the period 1960-1970; it is included to give the reader an idea of possible future helicopters of this payload weight class. The advantages of the

D216 are the reliability given it by its 3 engines, and the cargo handling facilities provided by its large rear cargo entrance and its long cargo compartment.

The cargo compartment is 6 feet by 6 feet by 24 feet. However, the cargo door will not allow this size package to be loaded. A rectangular package, including loading devices, 4 feet high by 6 feet wide by 24 feet long could be loaded, or a package 5 feet high 6 feet wide and 10 feet long.

The aircraft is provided with an external cargo sling. A payload-range graph (Fig 8) is given for both internal and external (with fuselage intact) loading.

This helicopter is in the design proposal stage, and it is unknown whether or not it will ever be produced.

XH-17: The Hughes XH-17 is a pressure jet type cargo helicopter, which is a radical departure from all previous helicopter designs. One such helicopter has been produced and flown. Since this is a new concept, it is believed that this helicopter will be of greater experimental value than it will be of practical value. Using the experience gained with the XH-17, better helicopters of this type may be developed. Already a proposal for the same general type of helicopter, the XHCH-1 (discussed later), is being considered for production by the Navy. Also, a report recently published by Hiller Helicopters shows that rotor tip propulsion, either by pressure jets

or turbojets, would be the best choice for production procurement in the period 1960-1970.

The pressure jet system consists of feeding compressed air through the rotors to the jets at the end of the blades. These jets propel the rotor. This type propulsion leads to a heavy-lift, short-range helicopter, the short range being due to the rapid rate of fuel consumption.

The XH-17 is built so that it can straddle most loads and carry them externally. This helicopter in its present stage can carry an 8,000-pound load, and it is thought that with a few minor changes the payload could be increased to 15,000 pounds. The Hughes Company believes it can develop a production model of this type capable of carrying up to 30,000 pounds over a distance of 100 miles.

XHCH-1: The McDonnell XHCH-1 is a cargo helicopter under active development for the U. S. Navy. It is designed for air lifting large payloads from ship to ship and ship to shore or from rear supply to forward combat areas. Payloads of over 13 tons may be lifted for short distances. Extended radius deliveries carrying reduced payloads are possible at over 100 nautical miles.

The XHCH-1 is powered by pressure jets. Two gas turbine engines with load compressors supply the required air flow to the jets located at the tips of the rotor blade. This helicopter has a very rapid

gas consumption; therefore, the payload curve declines rapidly with increased radius.

The cockpit arrangement is such that the co-pilot's seat faces the rear. There is a window in the floor which allows the co-pilot to see the cargo while handling the helicopter during pickup and deposit of the payload. The XHCH-1 is designed for external loading only.

Payload-radius curves can be found in Fig 9.

In Fig 9 a dual nozzle jet is mentioned. This is a concept where one nozzle is the actual pressure jet engine and the other nozzle is a release for the compressed air from the compressors. It has not yet been determined whether a single or double nozzle jet system will be used on the XHCH-1.

CONCLUSIONS

Period 1956-1960

The H-37A provides maximum cargo capabilities, with a payload of 6,000 pounds for a 100 mile radius. However, the H-37A production is just starting, and it will not be generally available until about 1959.

The H-21C is now in general use and in quantity production. Therefore, the H-21C should be used as a standard of cargo capabilities of helicopters for the present. Using this standard, packages designed for helicopter transport over a 100 mile radius should be limited to two tons in weight. If internal loading is necessary, the package should meet the requirements of the table on page 7.

If multi-lift experiments prove successful, the weight limits could be increased in proportion to the number of helicopters used.

To realize the advantages of external loading, especially in combat areas, packages should be designed to withstand and implement this type handling.

Period 1960-1970

The YH-16B and the XHCH-1 can be considered standards for the capabilities of cargo helicopters during this period. This means that for short hauls (i.e., 20 mile radius) a load of 22,000 pounds could be transported. For a 100 mile radius 16,700 pounds could be transported with a hovering ceiling of 5,600 feet.

For internal cargo loading the YH-16B can be considered the standard for maximum cargo dimensions. However, it is believed that most large cargo will be carried externally because of the ease of loading and unloading.

Although the YH-16B and the XHCH-1 may never go into production status, it seems almost inevitable that helicopters of this size will be produced.

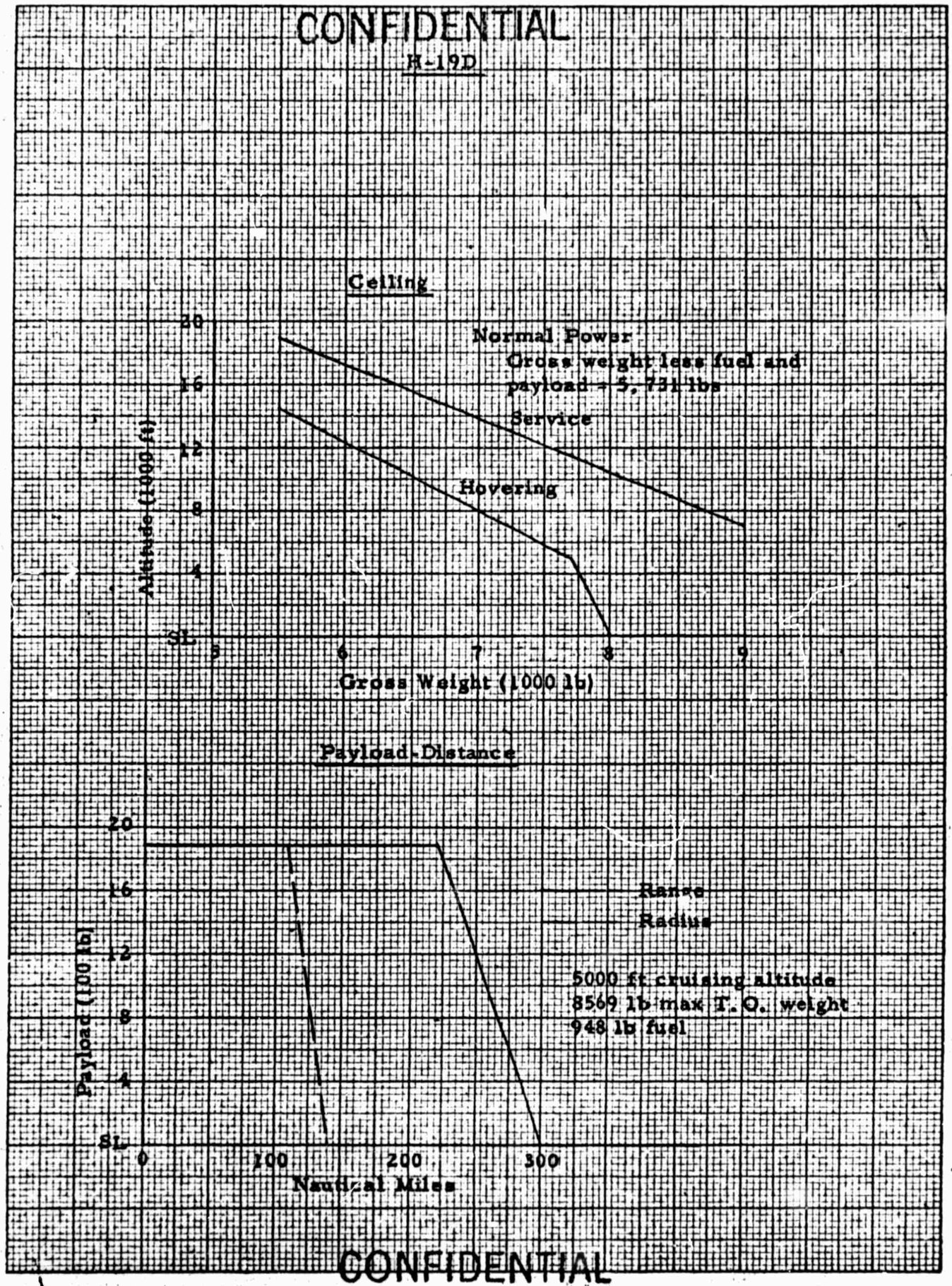

R-19D
Ceiling
Normal Power
Gross weight less fuel and payload = 5, 731 lbs
Service
Hovering
Altitude (1000 ft)
20
16
12
8
4
SL
5
6
7
8
9
Gross Weight (1000 lb)
Payload-Distance
Range Radius
5000 ft cruising altitude
8569 lb max T. O. weight
948 lb fuel
Payload (100 lb)
20
16
12
8
4
SL
0
100
200
300
Nautical Miles

Fig 2

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H-21C

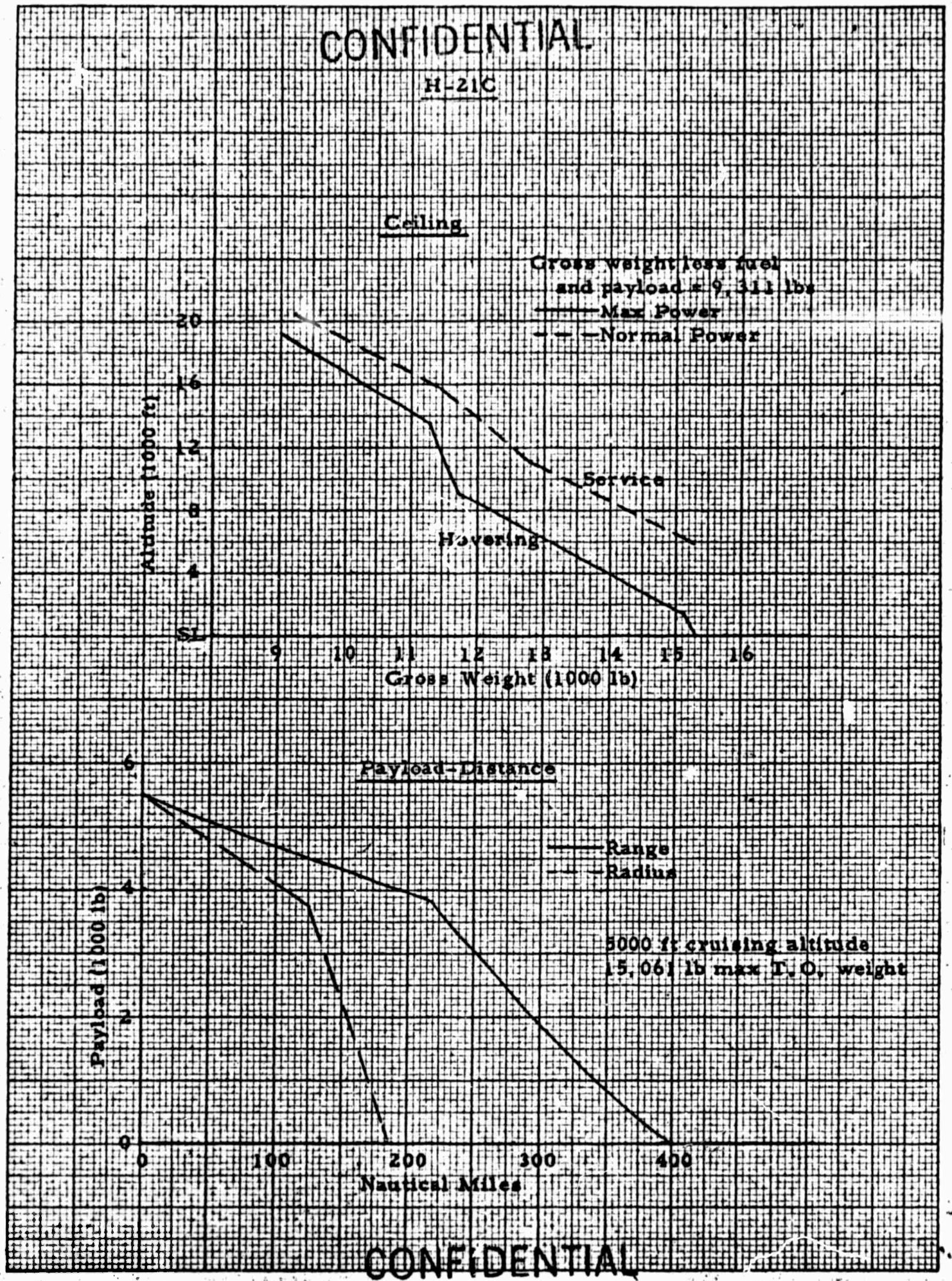

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Fig 3

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H-34A

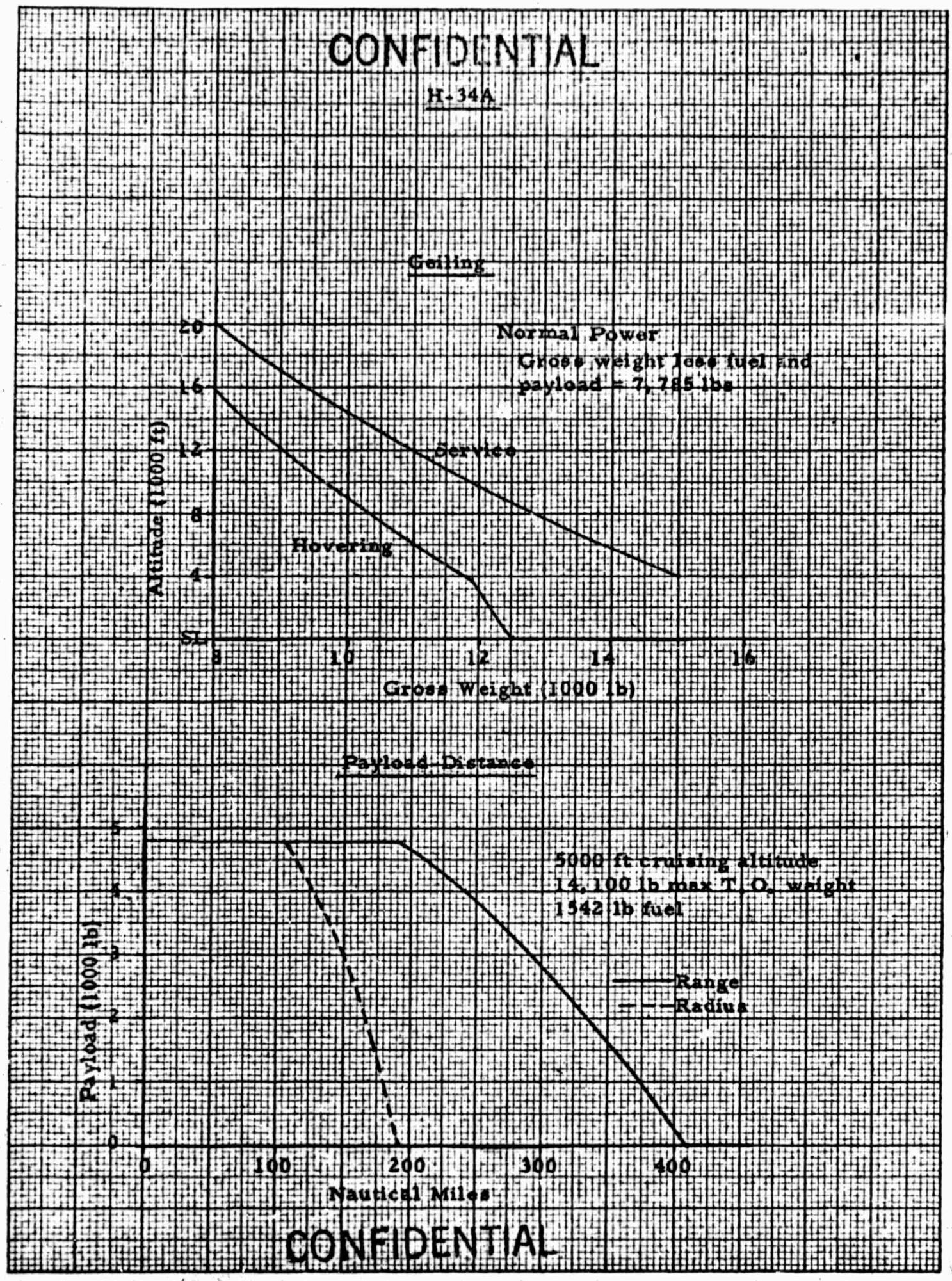

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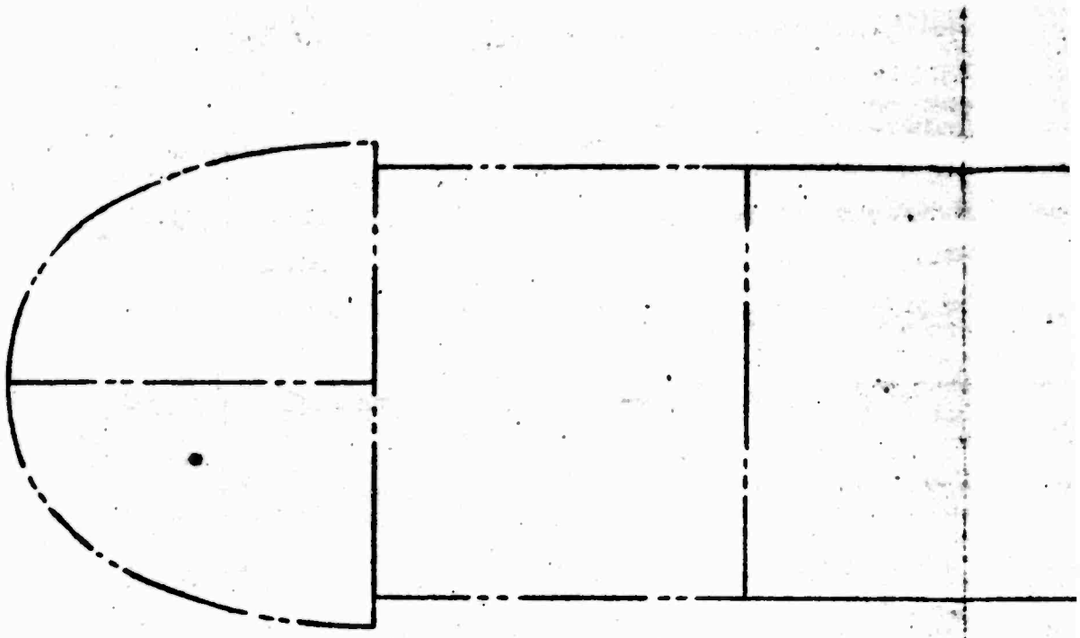
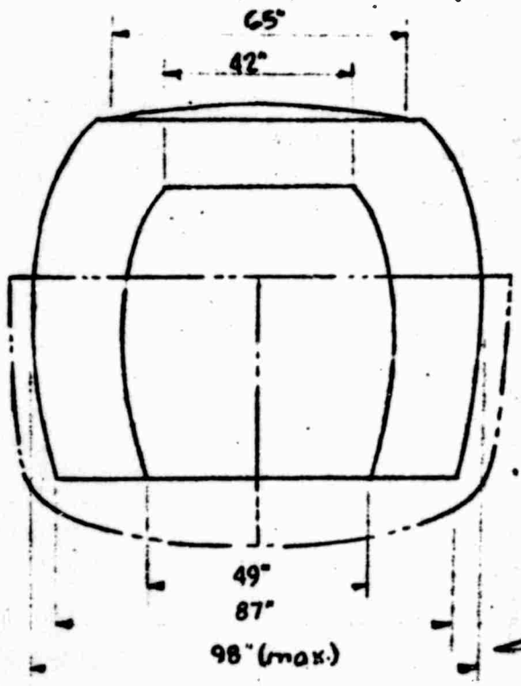
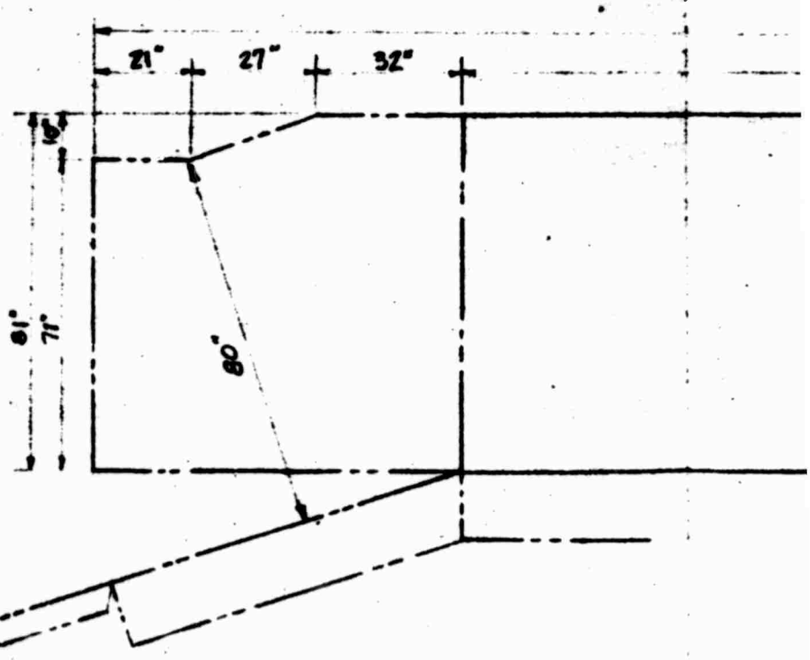
Fig 4







SCALE : 1/40

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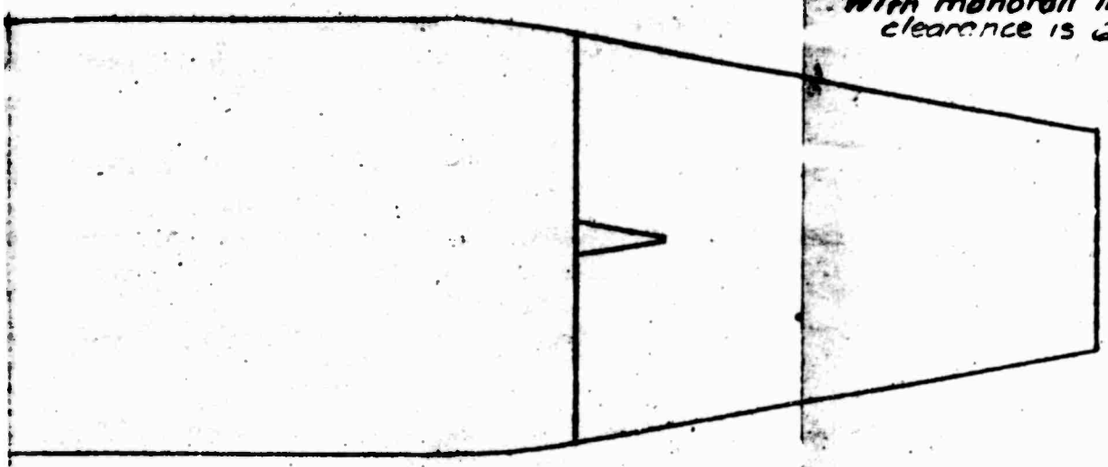
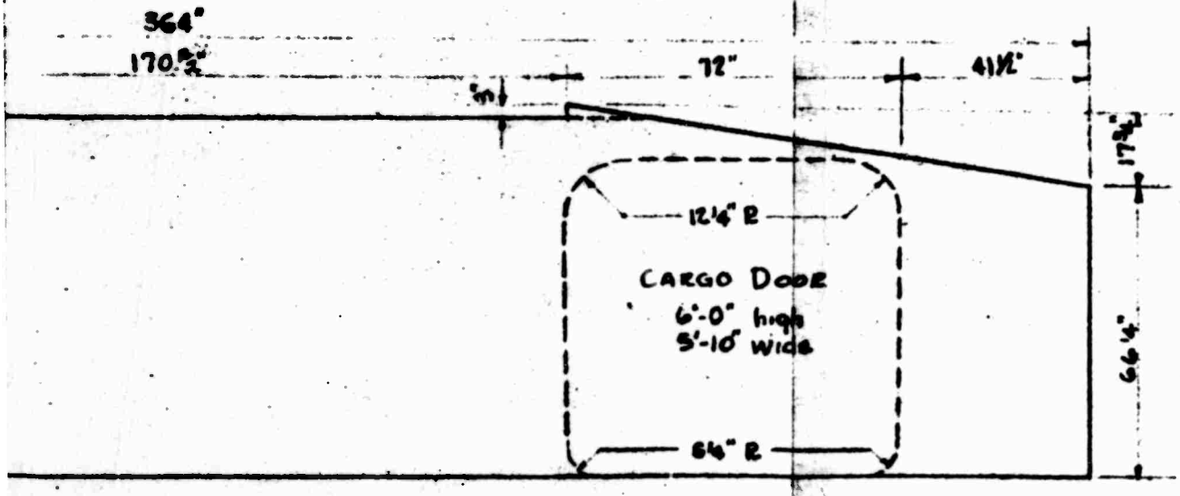
Cargo Comp't - Inside Dimensions

Length	[illegible]'-4"
Width	7'-3"
Height	6'-9"
Floor Area	202.3 sq. ft.
Volume	[illegible] cu. ft.
Max. Floor Load	300 psf

With monorail in position clearance is 6'-7".





CARGO COMPARTMENT SECTIONS

MODEL H-37A — HELICOPTER

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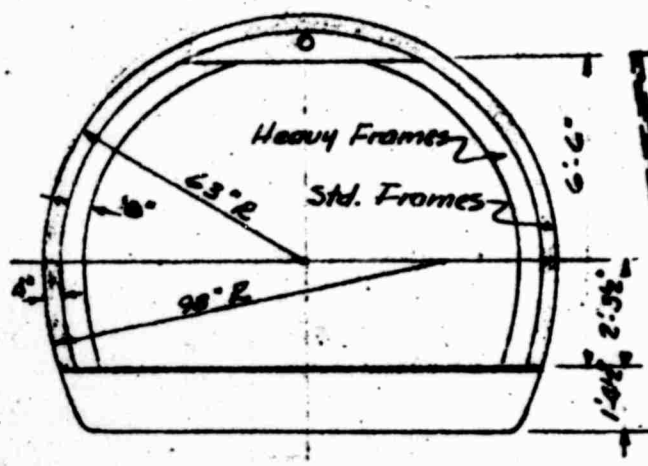
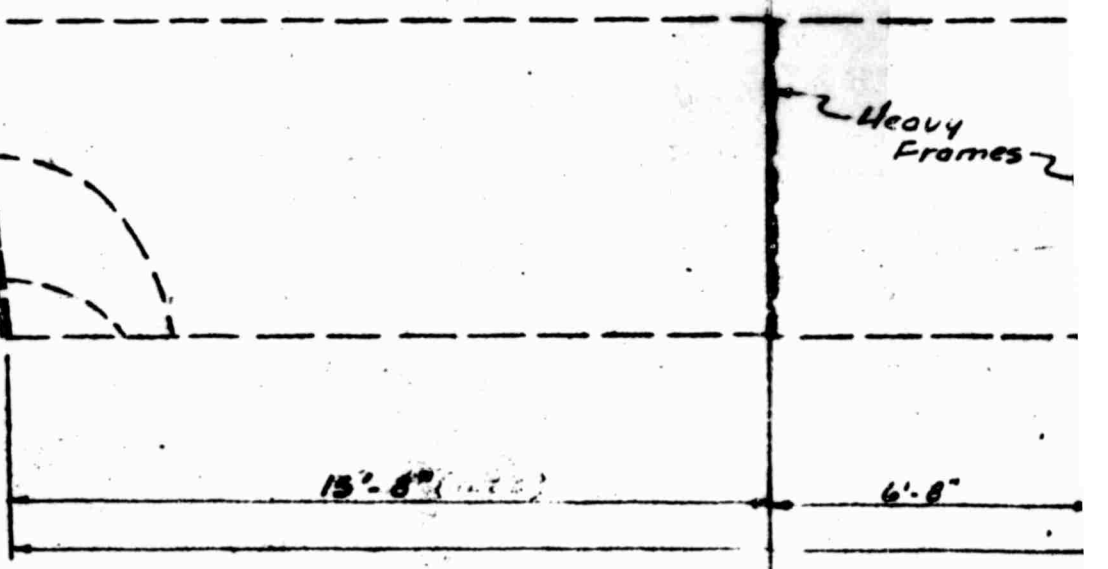
2

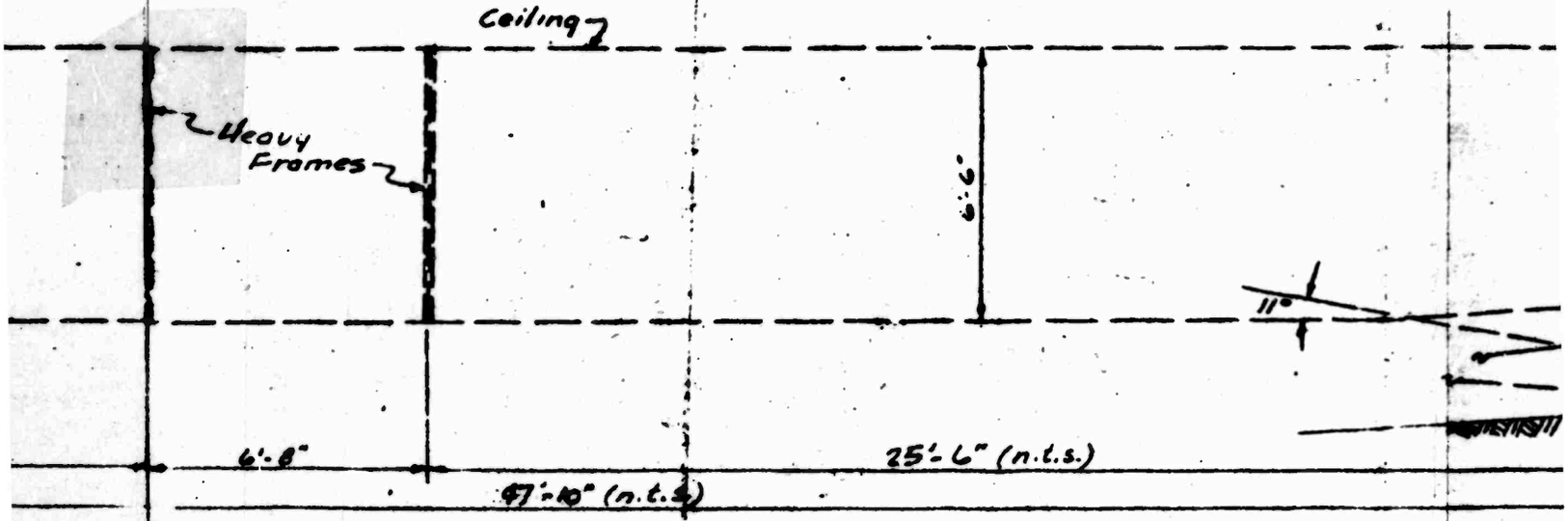
Fig 5





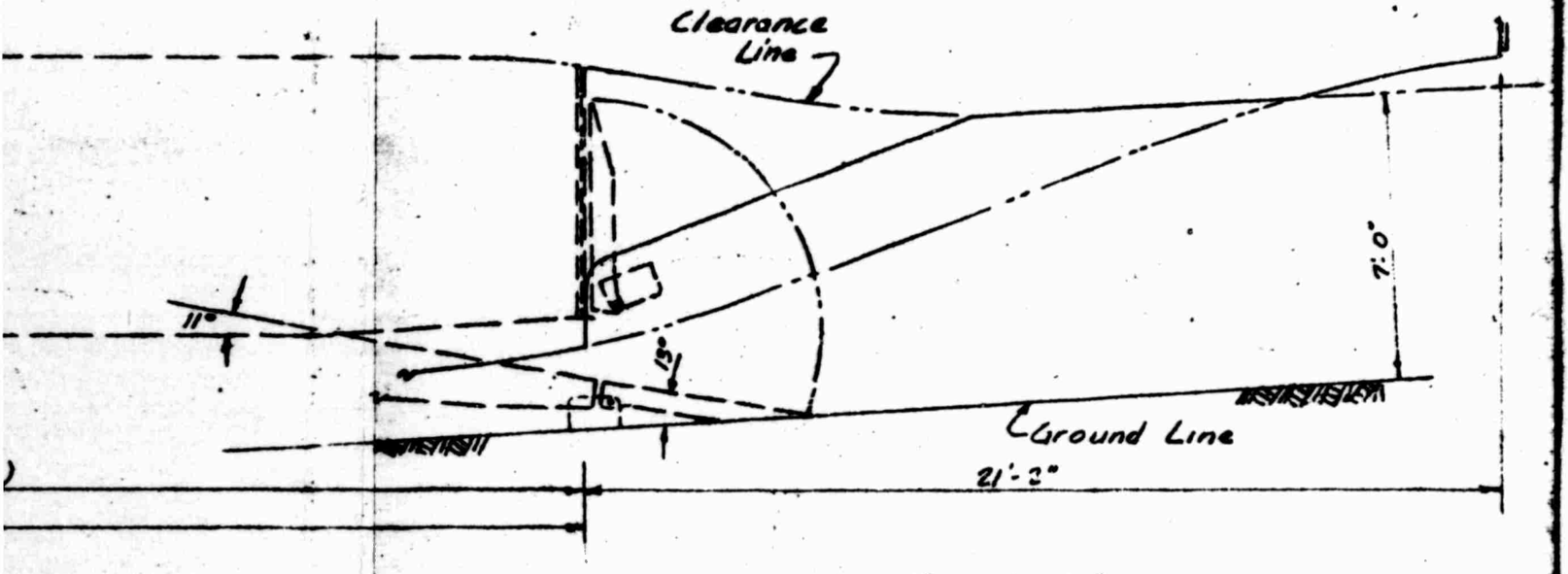
CARGO C

YH



CARGO COMPARTMENT

YH-16B



Scale: 1" = 50'

3

Fig 6.

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YH-16B TRANSPORT - CRANE - GROWTH CHART

NOTES: NORMAL GROSS WEIGHT
TRANSPORT – HOVERING 6000' 95°-10' OFF GRND at MIL HP
CRANE – HOVERING 6000' 95°-20' OFF GRND at MIL HP
OVERLOAD GROSS WEIGHT
TRANSPORT – HOVERING AT S.L. OUT-GRND EFF 100°F at MIL HP
CRANE
MAX. OVERLOAD GROSS WEIGHT
CRANE – HOVERING AT S.L. 100°-20' OFF GRND at MIL HP

MAX. GROSS WEIGHTS ARE DETERMINED BY POWER AS NOTED ABOVE OR BY BLADE LOADING

MISSION:
TRANSPORT 100 NAUTICAL MILE RADIUS
CRANE 20 NAUTICAL MILE RADIUS, 4 MIN. HOVER, 11 MIN. HOVER RESERVE

ITEM	UNITS	YH-16 B (2) YT56 TURBINES			FUTURE PROGRAMMED POWER INCREASE (2) YT56 TURBINES		YH-16B (GROWTH) (3) YT56 TURBINES		H-16 TYPE (4) YT56 TURBINES	
		TRANSPORT	CRANE	CRANE AUGMT. POWER	TRANSPORT	CRANE	TRANSPORT	CRANE	TRANSPORT	CRANE
ENG. HP/RPM (NRP)	SHP/RPM	3212	3212	3212	3510	3510	3212	3212	3212	3212
(MIL)	SHP/RPM	3620	3620	3620	3890	3890	3620	3620	3620	3620
ENG. HP/RPM 100° (NRP)	SHP/RPM	2660	2660	2660	2900	2900	2660	2660	2660	2660
(MIL)	SHP/RPM	2995	2995	2995 + 675	3210	3210	2995	2995	2960	2960
ENG. HP/RPM 95°/6000' (MIL)	SHP/RPM	2460	2460	2460	2630	2630	2460	2460	2460	2460
WEIGHT-EMPTY	LBS	31309	29166	29761	31529	29386	39514	37397	67166	62084
GROSS WEIGHT (NORMAL)	LBS	47630	46025		49500	48900	62000	60600	101300	99000
(OVERLOAD)	LBS	54700	55890	59900		58500	73000	70900		116000
(MAX. OVERLOAD)	LBS		58200			59900		73300		123800
USEFUL LOAD-TOTAL (NORMAL)	LBS	16321	16859		17971	19514	22486	23203	34134	36916
(OVERLOAD)	LBS	23391	26724	30139		29114	33486	33503		53916
(MAX. OVERLOAD)	LBS		29034			31614		35903		61716
USEFUL LOAD-FIXED	LBS	1057	1732	1774	1057	1732	1282	1957	2267	3092
PAYLOAD (NORMAL)	LBS	10734	13239		11979	15819	14654	18706	22736	29894
FUEL LOAD (NORMAL)	LBS	4530	1888		4935	1963	6550	2540	9129	3930
PAYLOAD (OVERLOAD)	LBS	17804	22912	25765		25233		28786	22736	46624
FUEL LOAD (OVERLOAD)	LBS	4530	2080	2600		2149		2760		4200
PAYLOAD (MAX. OVERLOAD)	LBS		25202			25516		31146		54286
FUEL LOAD (MAX. OVERLOAD)	LBS		2100			2266		2800		4338
		R-41'	V_T-674 f/SEC	G-.0563	R-41' V_T-674 f/SEC G-.0563		R-41'	V_T-674 f/SEC G-.0745	R-60'	V_T-696 f/SEC G-.08
R/C (NORMAL) VERT @ S.L. NRP	FPM	1450			1150		1868		1320	
BEST @ S.L. NRP	FPM	2200			2125		2710		2140	
HOVERING CEILING STD. DAY										
a) OUT OF GROUND EFFECT MRP	FT	10300			9200		11100		9700	
b) OUT OF GROUND EFFECT NRP	FT	8600			9000		9000		7700	
HOVERING CEILING MRP T_{amb} (95°F at ALT)										
a) WHEELS 10' OFF TRANS. 20' OFF CRANE	FT	6000			6000		6200		6000	
b) OUT OF GROUND EFFECT	FT	4400			4400		4500		3800	
SERVICE CEILINGS										
a) ALL ENGINES MRP	FT	15900			14500		16000		14500	
b) ALL ENGINES NRP	FT	14900			13800		15000		12100	
c) ONE ENGINE OUT COND. MRP	FT	6400			6600		11400			
d) ONE ENGINE OUT COND. NRP	FT	3000			3300		10000			
CRUISE SPEED										
a) SEA LEVEL	KNOTS	140			136		140			
b) 5000 FT	KNOTS	123			119		123			

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Fig 7

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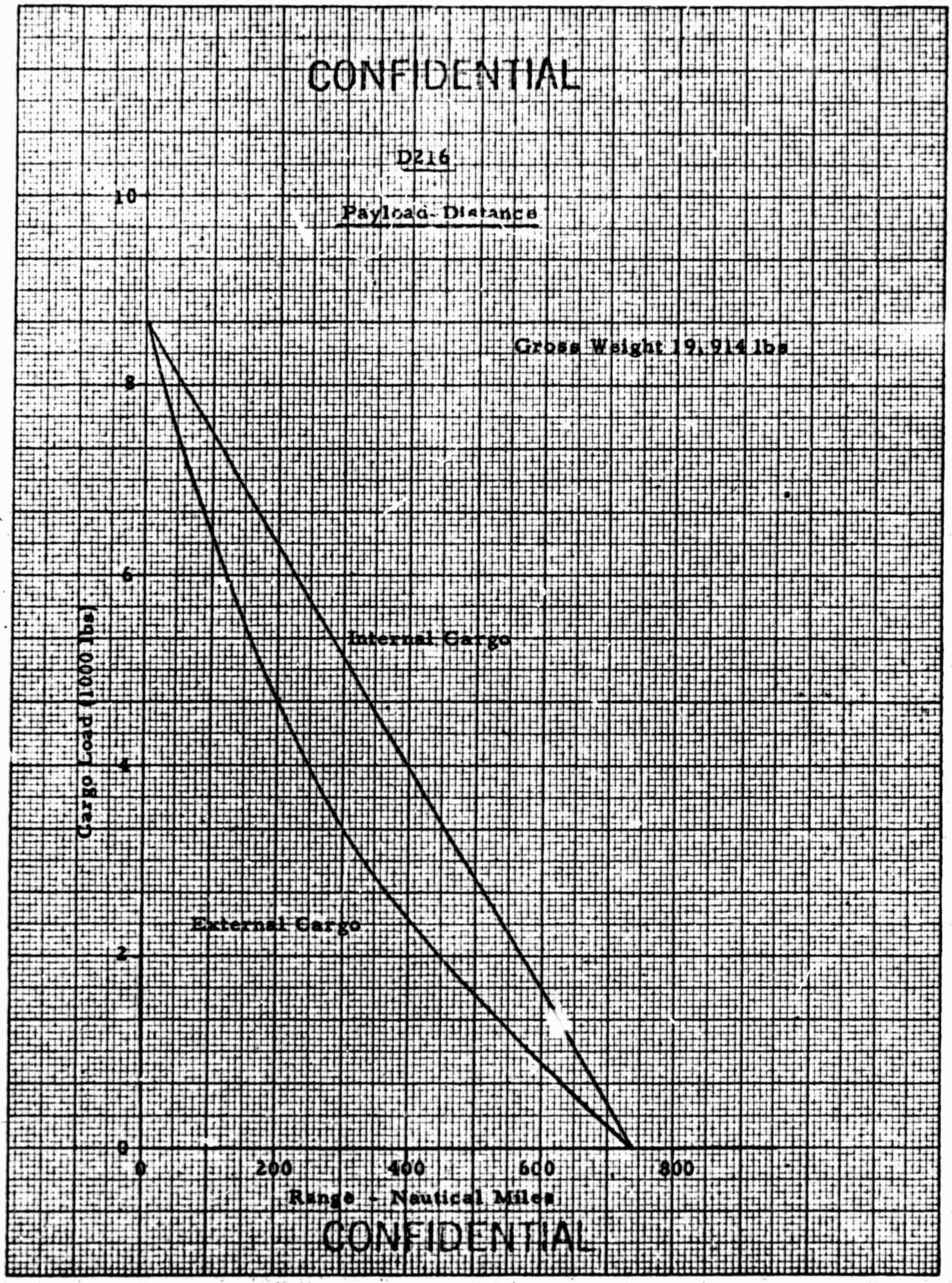

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Fig 8

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XHCH-1

Payload vs Combat Radius

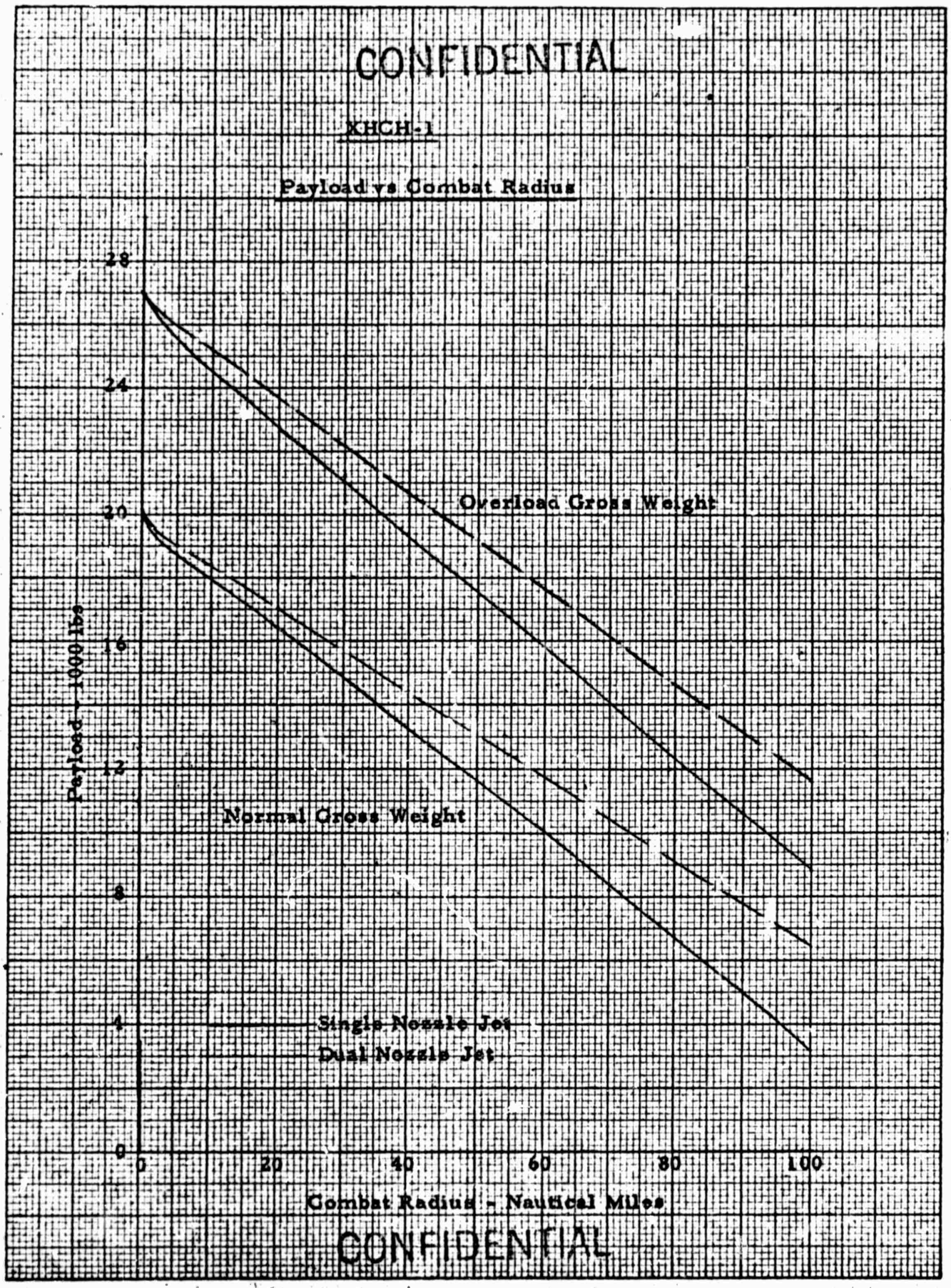

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Fig 9